Insect Diapause: Field and Insectary Studies of Six Lepidopterous Species

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ABSTRACT

Pink bollworm, *Pectinophora gossypiella* (Saunders), prepupae overwinter in free cocoons and in immature cotton bolls in Arizona. Emergence of the moths from overwintering prepupae extends from early spring to late summer, and emergence from free cocoons is generally earlier than from bolls. The major overwintering population is present in bolls from late September through October. Photoperiod, temperature, and moisture are apparently involved in the triggering, intensity, and termination of pink bollworm diapause. Bollworms, *Heliothis zea* (Boddie), tobacco budworms, *H. virescens* (F.), and saltmarsh caterpillars, *Estigmene acrea* (Drury), show a tendency toward summer diapause. Bollworm and tobacco budworm winter diapause is apparently triggered by photoperiod in late September and October, and termination is erratic after varying heat input. Saltmarsh caterpillar diapause is sporadic. This species could possibly survive Arizona winters in a nondiapausing condition if food were available. Beet armyworms, *Spodoptera exigua* (Hübner), and cabbage loopers, *Trichoplusia ni* (Hübner), displayed no winter diapause and apparently overwinter in Arizona in a nondiapausing state.

KEYWORDS: Insect diapause, insect dormancy, overwintering insects, pink bollworm diapause, bollworm diapause, tobacco budworm diapause, beet armyworm diapause, cabbage looper diapause, saltmarsh caterpillar diapause.

CONTENTS

INSECT DIAPAUSE: FIELD AND INSECTARY STUDIES OF SIX LEPIDOPTEROUS SPECIES

By R. E. Fye[1]

INTRODUCTION

In their discussion of current knowledge of diapause, Tauber and Tauber (*18*)[2] state "Although there exists much data on diapause induction, maintenance, and termination, only rarely can this information be related to events in the field because the data are derived from laboratory oriented studies." and "... even fewer of these studies have considered the changing seasonal conditions as they occur in nature and the changing physiological responses of the organisms throughout dormancy." The following studies were conducted under cage conditions approaching field conditions to provide data for detailed temperature and moisture analyses and insights into the diapausing behavior of the pink bollworm, *Pectinophora gossypiella* (Saunders); bollworm, *Heliothis zea* (Boddie); tobacco budworm, *H. virescens* (F.); beet armyworm, *Spodoptera exigua* (Hübner); cabbage looper, *Trichoplusia ni* (Hübner); and saltmarsh caterpillar, *Estigmene acrea* (Drury).

METHODS AND MATERIALS

Pink Bollworms in Winters from 1971 to 1975

On October 19, 1971, 175 green bolls containing pink bollworms were placed in each of 25 cages, 20 by 20 by 24 inches, and covered with vermiculite. These represented five replicates of five different treatments. The treatments were as follows: (1) Normal 1971-72 rainfall; (2) the 1971-72 rainfall supplemented with added water at the first of each month to bring the 1971-72 rainfall up to the normal (*16*) for the Tucson area; (3) the 1971-72 rainfall and a subirrigation on February 26, representing field irrigations by local growers; (4) the 1971-72 rainfall plus a thorough soaking in early March as a potential suicidal emergence trigger; and (5) the 1971-72 rainfall plus the subirrigation plus the regular irrigations representing irrigations by growers. The irrigations consisted of thoroughly soaking the bolls and the vermiculite around them with water. The cages were inspected three times weekly for the emergence of pink bollworm moths, and the number of emerged moths was recorded.

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[1]Research entomologist, Yakima Agricultural Research Laboratory, 3706 West Nob Hill Boulevard, Yakima, Wash. 98902.

[2]Italic numbers in parentheses refer to Literature Cited, p. 12.

In the falls of 1972 and 1973, 5,000 green bolls were picked at 10-day intervals between September 15 and November 5. In 1974, the bolls were picked at 2-week intervals between September 5 and November 4. The bolls were divided into groups of 1,250 and placed in large sheet metal funnels under which gallon cartons of vermiculite were suspended. The larvae exiting from the bolls fell into the cartons. The cartons of vermiculite were changed at 5-day intervals, thus, the age of the exiting larvae was known within 5 days. The cartons from each group were marked with the date they were removed and placed in the insectary and held until all fall moth emergence from the larvae collected from the bolls was complete. The cartons were checked in the insectary twice weekly, and the numbers of pink bollworm moths emerging were recorded. At the time the cotton plants in the field were frozen, the bolls were removed from the funnels and placed in conical or pyramidal cages under a slatted shade in the field. The cages were adjacent to deep trays on the soil surface in which the cartons of vermiculite that had been removed at 5-day intervals were placed and buried to the rim in a combination of vermiculite and soil. The cartons and the cages were checked once weekly for pink bollworm emergence throughout the winter and through the spring and summer.

In the 1971-72 study, samples of the vermiculite covering the bolls were taken weekly, and the amounts of moisture in the vermiculite were determined. In the 1972-73 experiment, samples of vermiculite were taken from the trays once a month between February and April, and the amounts of moisture were determined. In the 1973-74 and 1974-75 experiments, one-quart cartons of vermiculite were placed in the same situations as the gallon cartons containing the pink bollworm pupae, and single quart cartons of the vermiculite were removed at weekly intervals. The amount of moisture in the vermiculite was determined gravimetrically. In all three experiments, temperature probes of soil thermographs were inserted in representative locations in the cages or in the trays containing the cartons to maintain the continuous record of the temperatures within the cartons or cages. Thus, the records of the temperature and moisture in the hibernation cartons and cages were known in addition to the date of fall larval emergence within 5 days, and the moth emergence dates during the winter, spring, and summer were known within 7 days. Detailed physiological responses (*17*) were not evaluated.

Pink Bollworms in Winter of 1975-76

Green bolls for the diapause studies during the winter of 1975-76 were collected on October 14, 1975, and divided into 35 replicates of 275 bolls each. The bolls were placed in 2-gallon ice cream cartons, which were then filled with vermiculite to within one inch of the top of the carton. The cartons were then buried in deep boxes of vermiculite to within about one inch of the rim at the top.

Seven replicates were exposed to natural weather conditions of the winter. Seven replicates were buried in a box in which heating cables had been installed so that four passes of the cable were placed along each side of the carton. The cables were thermostatically controlled and were set so that when the temperature dropped below 10°C the cables were activated.

The limited system was unable to maintain the cartons at the set temperature but provided a means by which the heat input in the seven cartons was in excess

of the ambient heat input. Seven other cartons were placed under heavy shade, and only the early morning and late afternoon sun struck them. Therefore, the heat input was greatly reduced, particularly during the spring and summer.

The rainfall was simulated by wetting the cartons and the surrounding vermiculite from a sprinkling can containing the moisture equivalent of the rainfall. Seven replicates were also placed under a transparent shade and maintained under dry conditions, the cartons receiving only the moisture that blew under the shelter during thundershowers. Finally, seven cartons were buried in a deep tray, and the bolls and vermiculite were irrigated with the equivalent of one inch of water per month from November through May. The bolls and vermiculite were also exposed to the normal rainfall occurring in the area.

Temperatures within the overwintering situations were monitored with five thermocouples in each of the treatments with one additional thermocouple recording the ambient air temperature 4 feet above the ground in a small kiosk. Moisture was monitored at weekly intervals by removing one-quart cartons of vermiculite interspersed among the treatment cartons. Thus, a daily temperature record at 2-hr intervals and weekly moisture record were available. The temperatures were used to calculate the reciprocal units of development (RUD) (*6*), that is, the proportion of development at the prevailing temperature for each 2-hr period. On July 1, 1976, the shelters over the shaded and dry treatments were removed, and the ambient conditions prevailed for the remainder of the experimental time.

For the 1975-76 insectary experiment, 40 replicates of 150 green bolls each were collected on October 15 and placed in plastic storage boxes (15 by 11 by 6.5 inches) with ventilated lids. The bolls were covered with vermiculite, and 20 replicates were moistened with 61 in^3 of water each. Throughout the winter, the boxes in which moisture had been placed were maintained so that the vermiculite was in a relatively wet condition. The remaining 20 boxes were maintained in a dry condition with only the boll moisture present. The 40 replicates were maintained in an outdoor insectary under ambient air temperature and light conditions. The temperature was monitored in representative boxes of bolls with probes of soil thermographs.

Moth emergence was checked throughout the fall, winter, spring, and summer at weekly intervals in both the field and insectary experiments.

Other Species in Winter of 1971-72

For the study of diapause of the remaining five insects -- bollworm, tobacco budworm, beet armyworm, cabbage looper, and saltmarsh caterpillar -- pupae were withdrawn from the Cotton Insects Biological Laboratory cultures during early July of 1971. The pupae were maintained in the insectary in glass jars lined with plastic bags (*11*). The emerging moths were allowed to oviposit, and the eggs were held in the insectary until hatched.

After hatching, the larvae were placed in one-ounce cups of lima bean medium (*11*) and reared to the prepupal stage. Twice weekly, the cups containing the prepupae were opened and placed on screened trays over 2 inches of soil in deep plastic sweater boxes (15 by 11 by 6.5 inches) with the exterior painted black and covered with a ventilated clear plastic cover. For those pupating aerially,

that is, the cabbage loopers and saltmarsh caterpillars, wads of large wiping napkins were placed in the box with the prepupal insects. If the prepupae had not moved from the cups by the next introduction, they were moved to the subsequent pupal cage. Thus, the pupation date for the insects was known within a 3- to 4-day interval. The pupation cages were moistened whenever natural rainfall occurred in the Tucson area. The pupation cages were examined throughout the winter, spring, and summer of 1972.

The cultures were maintained in the insectary continuously, and the study insects were reared by placing newly hatched larvae in new cups once or twice weekly. Thus, the adults, larvae, and pupae were subjected to ambient temperatures and photoperiod. The rearing continued through the winter until mid-January. Therefore, the pupae represented a sequence produced from mid-July until mid-January. A continuous record of the temperatures within the insectary was maintained and was considered to represent the temperatures in the relatively thin layer of soil and the aerial temperature within the rearing and pupation cages.

RESULTS AND DISCUSSION

Pink Bollworms

The winter of 1971-72 was relatively dry with no measurable rainfall between December 27 and May 29. As compared with subsequent years, the emergence was relatively early and no significant differences in the total emergence under the several moisture regimens were evident (table 1). The total emergence in the irrigated treatment, however, was considerably higher and may be attributed to the higher moisture content of the substrate throughout the winter and into the early summer.

The moth emergence after the winter of 1972-73, presented in table 2 and figure 1, indicates that the major number of moths emerged from the pink bollworms overwintering in the bolls rather than from the free cocoons. Generally, the free cocoon emergence was earlier than emergence from the bolls. The moth emergence from bolls collected on September 15 and 25, 1972, indicates that few diapausing pink bollworms were present, and there were no significant peaks of emergence in the small numbers of moths emerging from the bolls. Emergence was scattered through June and July. An increased number of moths emerged from the bolls collected on October 5, 1972, with two peaks of emergence, one during the weeks of June 4 and July 16 when approximately 1.03 RUD and 2.36 RUD (*6*), respectively, had accumulated after the winter cold season. Many more moths emerged from the diapausing larvae in the collections of October 15, 25, and November 4. The emergence of moths from the free cocoons from boll collections of October 15 and 25 was somewhat earlier than moths from the diapausing larvae overwintering in the bolls. Peak emergence from the bolls collected on October 15 occurred on June 11 and July 23 after 1.25 RUD and 2.57 RUD, respectively, had accumulated. Similar emergence peaks from the bolls collected on October 25 occurred in early June and early July after about 1.25 to 1.90 RUD and 2.57 RUD, respectively, had accumulated after the winter cold season. No significant emergence occurred from the free cocoons from bolls collected on November 4; however, the emergence from diapausing individuals in the bolls was from June 4 to 18 after 1.03 to 1.44 RUD had accumulated and then on about July 16 when 2.35 to 2.57 RUD had accumulated.

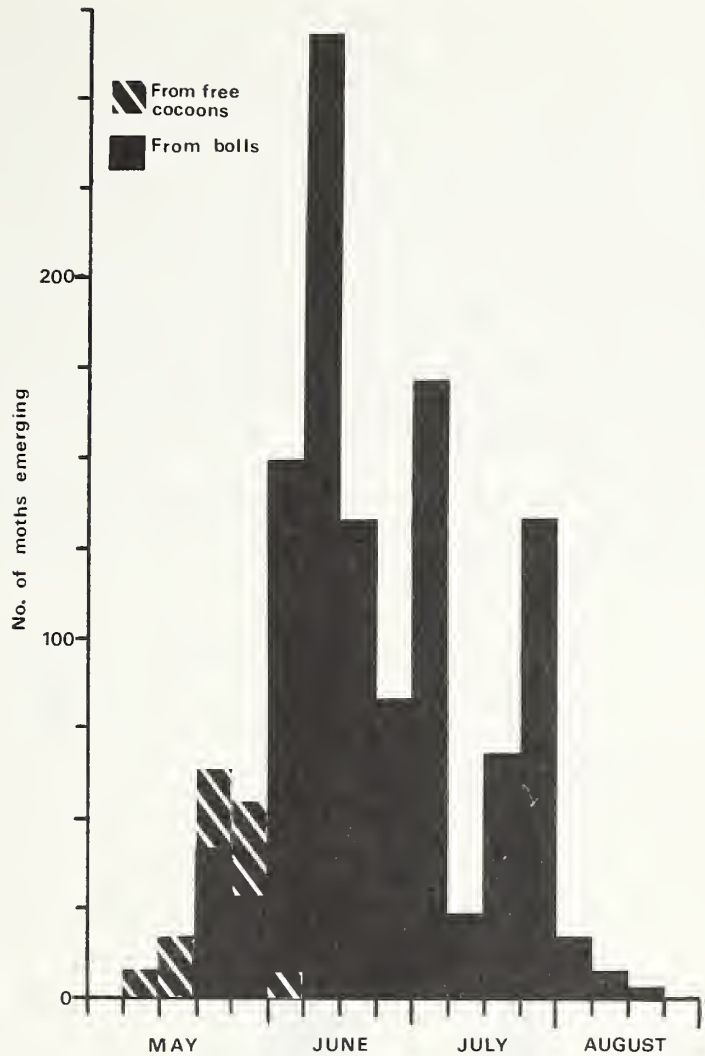

Figure 1.--Weekly emergence, in 1973, of pink bollworm moths from 30,000 bolls collected in the fall of 1972.

Thus, the summer emergence of moths from the overwintering prepupae appears to be bimodal after approximately 1.0 and 2.5 RUD have accumulated after the cold season.

These data are contrary to those presented by Sevacherian et al. (*14*) for the Imperial Valley of California and the Yuma area of Arizona where a continuous emergence was reported; however, the emergence concurs with the findings of Fife (*3*) for central Texas. The normal RUD required for the pupal period of pink bollworms is about 0.25 to 0.30 RUD; however, this criterion cannot be applied without some reservations because the precise triggers of the pupation from the prepupal stage are not known (*18*), and, therefore, the actual length of the pupal period could not be determined.

Moth emergence from the material held in the winter of 1973-74 was somewhat lower than that of the preceeding year. The winter was generally dry after December, and the lack of moisture may be responsible for the low survival rate

(table 3). The data presented in figure 2 again show less and earlier emergence from the free cocoons than from the bolls. The amount of emergence from the overwintering material from bolls collected on September 5, 1973, was relatively low, and no trends were evident. Emergence from the boll collection of September 15, 1973, was also poor with some emergence during the week of July 22, apparently triggered by the increased moisture of the substrate that was wet by the summer rains. RUD accumulation after the winter cold for this peak emergence, however, was about 2.60 and is in strong agreement with the accumulated RUD of the second peak emergence in 1973. There was no significant emergence from the boll collections of September 15, and October 5, 15, and 25 of 1973. Emergence of moths from the bolls collected on November 4, 1973, was scattered through June and early July with the peak emergence occurring the week ending July 22 when 2.60 RUD had accumulated, again agreeing with the accumulated RUD for the second peak emergence in 1973.

Emergence of moths from 1974 free cocoons in the spring of 1975 was generally earlier but more scattered through the season than in the prior 2 years; however, overall emergence of all moths was bimodal as in the prior 2 years

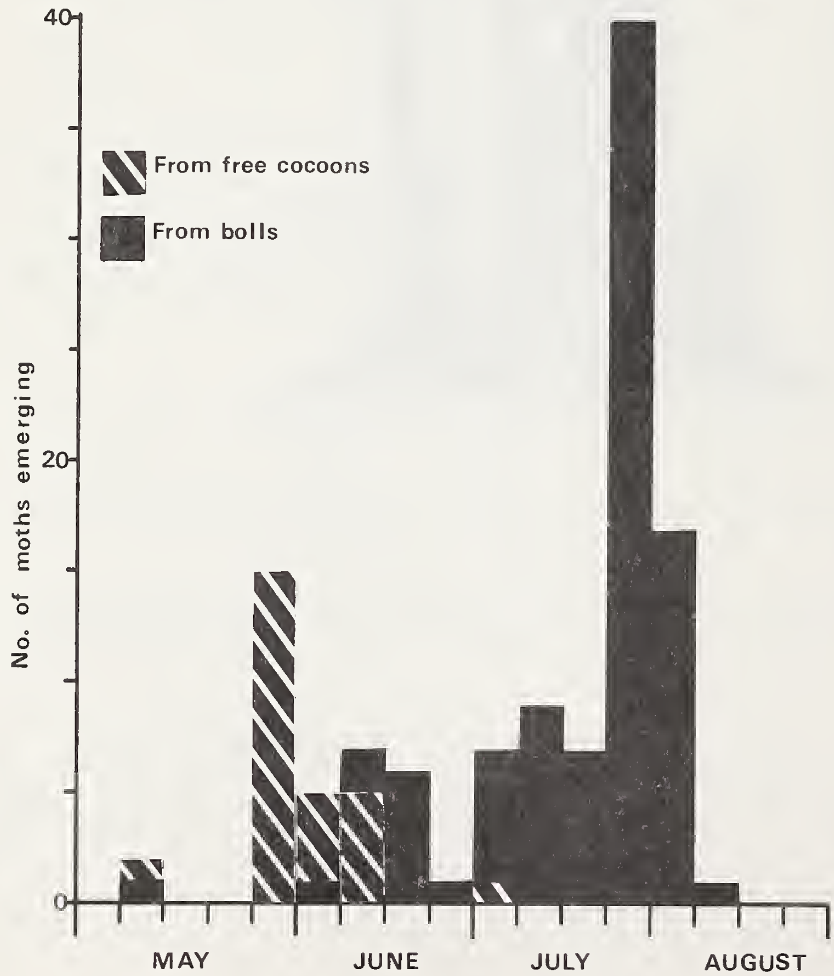

Figure 2.--Weekly emergence in 1974 of pink bollworm moths from 42,000 bolls collected in the fall of 1973.

(fig. 3). Few diapausing insects occurred in the collection of bolls from September 5, 1974, and emergence was somewhat scattered (table 4). Emergence from bolls collected September 19, 1974, was generally scattered through June and July; however, the peak occurred during the week ending July 29 when 2.5 RUD had accumulated. Emergence of moths from the material collected on October 3, 1974, peaked during the week of June 3 when 0.66 RUD had accumulated after the winter cold season and during the week ending July 29 when 2.51 RUD had accumulated. Very similar peaks occurred from the material collected on October 17 and 31, 1974, with peaks in the weeks ending June 3 and 10 when 0.66 to 0.88 RUD had accumulated and during the week ending July 29 when 2.51 RUD had accumulated. Thus, the earlier peak occurred with somewhat less accumulation of RUD than in the prior years, but assuming that the exact point of pupation cannot be determined as noted above, the smaller accumulation as compared with other years is probably not significant. The 2.50 accumulation of RUD for the material emerging during the week of July 29, however, concurs with the accumulation determined in the prior 2 years.

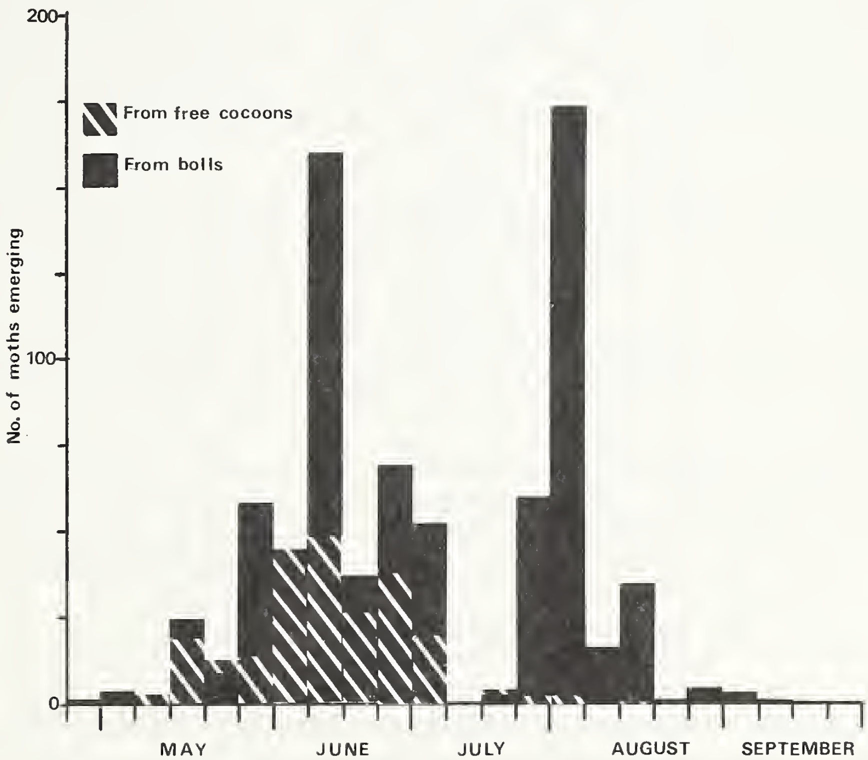

Figure 3.--Weekly emergence in 1975 of pink bollworm moths from 25,000 bolls collected in the fall of 1974.

Emergence from the pink bollworm moth material collected October 14, 1975, and treated similarly to the experiments in the prior 3 years peaked during the weeks of May 5 and 12 and May 26 and June 2 and 9. Accumulated RUD for the early peak was about 1.16 RUD and for the second peak was from about 1.57 to 2.01 RUD. Thus, the first peak occurred after accumulation of RUD similar to the previous 3 years, but the second peak occurred after a smaller RUD accumulation. Emergence from the replicates that were heated was relatively low, prob-

ably due to the low moisture content of the substrate; however, the peaks occurred on March 24, April 14, and June 9 after accumulations of 1.46, 1.98, and 3.57 RUD, respectively. Interestingly enough, the final moth emerged after an accumulation of 5.00 RUD. Emergence from the material that was shaded was considerably better probably due to a more favorable moisture content of the substrate. The major emergence occurred from June 6 to 16 after accumulations of 1.05 to 1.46 RUD. The proportion of moths emerging before the end of January was appreciably greater in the bolls held under dry conditions.

These data suggest that the moisture content of the substrate may appreciably affect the triggering or intensity of diapause of the pink bollworms. The peak summer emergence occurred during the week of May 26 and June 9 after 1.85 and 2.29 RUD had accumulated. The emergence from bolls held under wet conditions was relatively poor in both the field and insectary experiments and probably may be attributed to the packing of the vermiculite substrate to a degree that did not allow the emergence of the adult moths. Peak emergence from the material held under wet conditions occurred during the weeks of April 28 and May 5, May 19, and June 2, after accumulations of 1.03 to 1.23, 1.64, and 2.08 RUD had accumulated. Thus, the accumulated RUD for the early emergence generally agreed with the accumulated RUD of the previous three seasons, but the second peak was not as obvious, and the RUD accumulations were somewhat lower than in the prior 3 years.

In the insectary experiment, peak emergence during the dry conditions occurred from May 19 to June 3 after accumulations of 1.17 to 2.12 reciprocal units of development. A later peak, during the week of July 28, occurred after an accumulation of 3.25 RUD, thus approximating the bimodal emergence of prior years, although peaks were not as distinctly defined. A much lower emergence occurred under the very wet conditions, and emergence was completed relatively early in the season.

The overwintering survival of pink bollworms from boll collections from 1971 to 1974 indicates that the major number of pink bollworms in diapause are present during late September and all of October. These dates agree with the general concepts of pink bollworm diapause (*10*). Data presented in figures 1, 2, and 3, however, indicating that overwintering pink bollworms in free cocoons do survive successfully and are present when cotton is available for infestation, are contrary to the data presented by Chapman et al. (*2*) for Brownsville, Tex. Apparently, the less tropical situation in Arizona is not conducive to early emergence although some have been trapped during the warmer periods in Arizona winters (Fye, unpublished data).

The triggers that terminate diapause in the pink bollworm remain nebulous. The data presented above, showing that in moister, but not excessively wet situations, a larger number of pink bollworms will survive, agree with the discussion of Noble (*10*). In addition, the contentions of Wellso and Adkisson (*20*) that pupae in wet situations pupate more rapidly than those in dry is supported by the insectary experiment in 1975-76 (table 5); however, the field emergence in the same years fails to demonstrate earlier emergence in the wet situation suggesting an interrelationship with temperature. The long spread of emergence, previously noted by Fife (*3*) in Texas during several years, also demonstrates that dry conditions are less favorable for pupation of the pink bollworms as noted by Watson et al. (*19*) in Arizona and supports the contention of Slosser

and Watson (*15*) that soil either too wet or too dry may be detrimental to pink bollworm survival. The data also suggest that moisture may have some influence on the initiation, termination, and intensity of the diapause. The evidence that moisture during the late spring is essential to proper pink bollworm pupation and emergence was supported by the scattered, prolonged emergence in the summer of 1975 after a dry winter (table 4) and the subsequent emergence of between 25 to 30 moths during early June of 1976 from material placed in hibernation in the fall of 1974. Thus, in spite of the notation by Noble (*10*) that no pink bollworm had survived two winters in the field, the pink bollworms demonstrated the capability to do so under the slightly modified conditions of the experimental procedures. The bimodal distribution of emergence during several years, previously noted by Fife (*9*), also suggests that the genetic selection performed by Langston and Watson (*9*) may have even deeper implications than the original work suggested. Fife (*3*) suggested that summer rains triggered the second peak of emergence. The second peaks in 1973, 1974, 1975 occurred 1 to 2 weeks after major summer rainfall, and the secondary peak, during the early emergence in June 1973, occurred one week after an 0.25-inch rainfall. These periods are generally shorter than the 16 to 25 days after rainfall noted by Fife (*3*); however, higher Arizona soil temperatures may have expedited development during the pupal period. The remaining major questions as to why a segment of the overal population fails to emerge with the remainder in early summer is left unanswered; however, two distinct diapausing populations may exist within the pink bollworm population in Arizona. Evidently, spring and and summer emergence of pink bollworm populations under certain conditions is not as discreet as that described by Sevacherian et al. (*14*) in the Imperial Valley of California.

Regardless of the conditions under which a pink bollworm enters or terminates diapause, the pink bolworm is evidently well adapted to overcome adverse southwestern desert climates. The apparent responses of the pink bollworm to light, moisture, and temperature appear relatively complex as compared with those of many other insects, and, therefore, until further knowledge of the subject of pink bollworm diapause is accumulated, the pink bollworm cannot be categorized in any of the three categories suggested by Tauber and Tauber (*18*) for temperate climate species.

Bollworms

The bollworms originating from newly hatched larvae in the second 2 weeks of July 1971 (table 6) included relatively large numbers with normal accumulations of RUD (0.5 to 0.6) for the pupal period because many of the moths with pupal RUD accumulations of 0.7 to 0.8 must be considered normal due to the rapid accumulation of RUD during warm weather and the infrequency of the inspection interval. A number of the moths, however, emerged after RUD accumulations of 0.9 to 2.4, which suggests some tendency toward a summer diapause for bollworms developing during the hotter part of the Arizona summer. This tendency had virtually disappeared from individuals hatching in late August 1971 (table 6), but a full winter diapause was evident in a single individual.

Similar results were obtained with insects hatching in the first 2 weeks of September. Three individuals originating diapause during that period passed the entire winter without emerging. A much larger proportion of the insects originating during the last 2 weeks of September and the first 3 weeks of Octo-

ber diapaused. Similar results were obtained with larvae collected from silage corn near Amado, Ariz., in the fall of 1973 with the major winter diapausing population initiating from October pupae. The spring emergence, however, was generally concentrated in late March with less scattered emergence than on the insectary experiment (tables 6 and 7). Two of the insects from the insectary experiment originating in late October of 1972 and those in November, December, and January showed a very weak diapause and appeared to have overwintered with a markedly reduced developmental rate. Their accumulated RUD probably approached the 0.5 normal RUD accumulation for pupal development because late spring accumulations are rapid and the interval between inspections was relatively long.

During the period that the eggs were laid for the major diapausing segment of the population, the adult moths and eggs were exposed to photoperiods of from 12.5 to slightly over 11 hr of daylight. The larvae were exposed to from 12.5 to 11 to slightly over 10 hr of daylight. Thus, the long day requirement of the adult egg stages and shorter larval periods suggested by Roach and Adkisson (*13*) were met. With allowances for the more southerly location of Brownsville, Tex., the photoperiods are similar to those determined by Graham and Fife (*8*) to be necessary for diapause in that area, and, apparently, segments of the Arizona population also have the capability of reproducing through the winter if hosts are available. The data also corroborate the previous findings of Benschoter (*1*), Phillips and Newsom (*12*), and Fye and Carranza (*5*) in regard to photoperiod induction of diapause in bollworm. The inconsistencies in the intensity of diapause noted by Fye and Carranza (*5*) were also noted in the current study.

Tobacco Budworms

The tobacco budworms hatching in the second 2 weeks of July 1971 displayed a slight tendency for the summer diapause noted earlier (*7*). None of the tobacco budworms originating during August appeared to have a marked diapause, and the accumulated RUD was only slightly in excess of the 0.5 accumulation normally required by nondiapausing individuals. A relatively larger proportion of the individuals hatching in late September displayed winter diapause as did those originating throughout October. The spring accumulations of RUD required for emergence were variable for both groups (table 6). All of the tobacco budworms originating in November and December overwintered. Some showed marked diapausing tendencies, whereas others appeared to have overwintered in a relatively easily broken diapause or with a reduced developmental rate alone.

The data for tobacco budworms are similar but somewhat more variable than the data for bollworms. The same induction and termination stimuli appeared to control the diapausing functions of bollworms and tobacco budworms. The data corroborate the findings of Benschoter (*1*), Phillips and Newsom (*12*), and Fye and Carranza (*5*). Although *H. zea* is a common species in temperate zones, the Arizona populations of *H. zea* and *H. virescens* cannot be categorized in the temperate zone categories suggested by Tauber and Tauber (*18*) with the data presented.

Beet Armyworms

No true diapause appeared to occur in the beet armyworms reared from July through January. This species appears to successfully overwinter with a reduced

developmental rate with all stages capable of overwintering. The data corroborate the previous observations of Fye and Carranza (*5*).

Cabbage Loopers

No winter pupal diapause was apparent in the cabbage loopers reared in the test; however, the accumulated RUD for a number of the insects hatching during the second 2 weeks of July (0.7 to 1.3) and August appeared to be in considerable excess of the normal 0.4 accumulated RUD for nondiapausing individuals (*6*). Thus, a summer diapause tendency is suggested. Virtually all cabbage loopers reared from eggs hatching from September 1971 to January 1972 emerged after normal accumulated RUD for nondiapausing individuals with the prolonged pupal periods falling within the range of nondiapausing populations (*4*, *6*). Thus, the cabbage looper appears to overwinter in Arizona in a nondiapausing condition, and the development of the loopers during the winter months indicates that if plant hosts were available, a continuous population in all stages could occur.

Saltmarsh Caterpillars

Saltmarsh caterpillars, *Estigmene acrea* (Drury), displayed a rather erratic emergence in regard to RUD. This tendency has been noted (*4*, *6*), and the species seems to have varied responses to heat input (Fye, unpublished data). The normal accumulated RUD for pupal period of the saltmarsh caterpillar is about 0.35 (*6*). Due to the rapid accumulation of RUD during summer days and the infrequency of inspection intervals, accumulations of RUD up to about 0.5 to 0.6 could be expected for normal pupal period; however, a number of the individuals originating in the second 2 weeks of July and during the month of August emerged after periods in excess of the expected accumulated RUD. Therefore, some tendency toward a summer diapause is suggested. A large proportion of the individuals hatching during September were in full winter diapause as were a small proportion originating in December; however, the intensity of the diapause seems to be highly variable in this species, and, under ideal food and temperature conditions, some could survive winters in Arizona in a nondiapausing state.

CONCLUSIONS

The phenomenon of diapause in the species included in this study is obviously complex and under multivariate control. The studies demonstrated, again, the problems associated with developing experimentation that satisfactorily delineates the roles of physical and biological factors controlling diapause. The results parallel the previous findings of Fife (*3*) that showed two peaks in the summer emergence of pink bollworms with emergence extended into late summer. The variable intensity of diapause in bollworms and tobacco budworms described by Fye and Carranza (*5*) and the lack of diapause in beet armyworms was also corroborated; however, the variability of the data indicates that more refined technique and analysis will be required to delineate the roles of the various factors triggering and terminating diapause. Until the diapause facet of insect behavior is clearly defined, spring emergence cannot be predicted effectively, and the demands of modern insect population dynamics (*4*) cannot be met.

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APPENDIX TABLES

TABLE 1.--*Pink bollworm moth emergence from 250 bolls picked October 19, 1971*

Week of	1971-72 rain-fall	Treatment-- Normal rainfall[1]			1971-72 rainfall		1971-72 rainfall plus subirrigation			1971-72 rainfall plus March irrigation			1971-72 rainfall plus all irrigations		
		Irri-gation[2]	Substrate moisture[3]	Moths emerged	Substrate moisture	Moths emerged	Irri-gation	Substrate moisture	Moths emerged	Irri-gation	Substrate moisture	Moths emerged	Irri-gation	Substrate moisture	Moths emerged
1971	*Inch*	*Inch*	*Percent*	*Number*	*Percent*	*Number*	*Inch*	*Percent*	*Number*	*Inch*	*Percent*	*Number*	*Inch*	*Percent*	*Number*
Nov. 22	0.76		239		239			239			239			239	
29			144		144			144			144			144	
Dec. 6	.58		277		277			277			277			277	
13	.72		199		199			199			199			199	
20	.36		236		236			236			236			236	
27	.18		205		205			205			205			205	
Jan. 3			144		144			144			144			144	
10			124		124			124			124			124	
17			76		76			76			76			76	
24			64		64			64			64			64	
31			32		32			32			32			32	
Feb. 7		0.79	155		9			9			9			9	
14			156		30			30			30			30	
21			111		41			41			41			41	
28			37		15		1.00	179			15		1.00	179	
Mar. 6		.88	241		23			75			23			75	
13			109		6			41			6			41	
20			53		15	1		17		1.00	122	1		17	
27			47	3	14	0		10	1		42	2		10	3
Apr. 3		.73	178	5	8	5		10	6		36	7		10	12
10			64	2	11	1		9	4		14	2		9	4
17			29	11	5	1		6	0		5	5	1.00	160	5
24			5	9	4	0		7	2		5	3		53	4
May 1		.39	56	4	6	2		5	2		4	6		33	4
8			5	3	5	0		5	1		5	1	1.00	140	2
15			5	2	5	2		6	2		6	0		65	9
22			4	2	5	0		3	2		5	0		24	9
29	.10		2	0	3	0		3	0		3	0		3	3
June 5	.18	.03	27	0	33	0		31	0		18	0	1.00	15	10
12	.52		55	0	39	0		51	0		58	0		132	2
19	.13		3	0	3	0		3	1		2	0		35	0
26			27	0	33	0		31	0		18	0		15	1

[1]Based on Tucson mean rainfall 1891-1954 (*16*).
[2]To bring monthly rainfall to mean.
[3]The blown mica substance will retain water several times its own weight.

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*

Week ending	Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending--									Number of moths emerging from bolls
			Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	
			Boll collection of Sept. 15, 1972									
Oct. 16	0.6546	3.31 [1]	207	2	0							
23	.7045	2.28	36	2	0							
30	.7183	Trace	0	0	0							
Nov. 6	.7214		0	1	1							
13	.7231	.83	7	0	1							
20	.7233	.18	0	0	0							
27	.7233	.53	0	1	0							
Dec.	.7233	1.73										
Jan.	.7233											
Feb.	.7279	1.17										
Mar.	.7383	2.30										
Apr. 1-23	.8432	.10										
Apr. 30	.9280											
May 7	1.0070	.05										
14	1.1560											
21	1.3131											1
28	1.5372		1									
June 4	1.7489											1
11	1.9747											2
18	2.1636	.25										
25	2.3847											
July 2	2.6246											
9	2.8620	.50										
16	3.0766	1.65										
23	3.2968											6
30	3.4905	.78										1

See footnotes at end of table.

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*--Continued

Week ending	Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending-- Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	Number of moths emerging from bolls
Boll collection of Sept. 25, 1972												
Oct. 16	0.4446	2.95[1]	22									
23	.4945	2.28	17									
30	.5083	Trace	1									
Nov. 6	.5114		7	4								
13	.5131	.83	3	4								
20	.5133	.18	0	3								
27	.5133	.53	5	1								
Dec.	.5133	1.73										
Jan.	.5133		1	1	1							
Feb.	.5179	1.17										
Mar.	.5283	2.30										
Apr. 1-23	.6332	.10										
Apr. 30	.7180											
May 7	.7970	.05										
14	.9060											
21	1.1031		3									1
28	1.3272		3	4	2							
June 4	1.5389		3									
11	1.7647											1
18	1.9536	.25										1
25	2.1747											2
July 2	2.4146											0
9	2.6520	.50										2
16	2.8666	1.65										0
23	3.0868											2
30	3.2805	.78										

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*--Continued

Week ending	Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending-- Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	Number of moths emerging from bolls
			Boll collection of October 5, 1972									
Nov. 6	0.2661	3.22 [1]			5							
13	.2678	.83			7							
20	.2680	.18			12							
27	.2680	.53			6	1						
Dec.	.2680	1.73			12	3						
Jan.	.2680				1							
Feb.	.2726	1.17										
Mar.	.2830	2.30										
Apr. 1-23	.3879	.10										
Apr. 30	.4727											
May 7	.5517	.05										
14	.7007				3							
21	.8578				5							2
28	1.0819				6			1		1		1
June 4	1.2936				1			3	2			14
11	1.5194				2			1				7
18	1.7083	.25										3
25	1.9294											
July 2	2.1693											
9	2.0467	.50										
16	2.6213	1.65										3
23	2.8415											9
30	3.0352	.78										2
Aug. 6	3.2944											0
13	3.5279											1

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*--Continued

Week ending		Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending-- Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	Number of moths emerging from bolls
				Boll collection of October 15, 1972									
Nov.	13	0.0887	3.52 [1]				2						
	20	.0889	.18										
	27	.0889	.53										
Dec.		.0889	1.73				3						
Jan.		.0889					2						
Feb.		.0935	1.17										
Mar.		.1039	2.30										
Apr.	1-23	.2088											
Apr.	30	.2936											
May	7	.3726	.05										
	14	.5216					2	1	1				
	21	.6787					3	4	0				5
	28	.9028					13	12	1	4	2		6
June	4	1.1145					12	9			2		10
	11	1.3403					1	1					44
	18	1.5292	.25										22
	25	1.7503											15
July	2	2.2276											13
	9	2.4422	.50										
	16	2.6624	1.65										1
	23	2.8561											16
	30	3.1153	.78										

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*--Continued

Week ending		Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending--									Number of moths emerging from bolls
				Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	
Boll collection of October 25, 1972													
Nov.		0.0130	1.54 [1]										
Dec.		.0130	1.73										
Jan.		.0130											
Feb.		.0176	1.17										
Mar.		.0280	2.30										
Apr.	1-23	.1329											
Apr.	30	.2177											
May	7	.2967	.05										
	14	.4457											
	21	.6028								2			10
	28	.8269								7	3	4	4
June	4	1.0386						5	8	1	3		55
	11	1.2644						1	1		1		89
	18	1.4533	.25										55
	25	1.6744											33
July	2	1.9143											112
	9	2.1517	.50										12
	16	2.3663	1.65										37
	23	2.5865											76
	30	2.7802											6
Aug.	6	3.0394											2
	13	3.2729											2

TABLE 2.--*Pink bollworm moth emergence with temperature and moisture data 1972-73*--Continued

Week ending	Accumulated RUD	Inches of rainfall	Number of moths emerging from free cocoons initiating in the 10-day period ending-- Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Dec. 4	Dec. 9	Number of moths emerging from bolls
			Boll collection of November 4, 1972									
Nov.	0.0047	1.54 [1]										
Dec.	.0047	1.73										
Jan.	.0047											
Feb.	.0093	1.17										
Mar.	.0197	2.30										
Apr. 1-23	.1246											
Apr. 30	.2094											
May 7	.2884	.05										
14	.4374							1				
21	.5945											17
28	.8186									1		17
June 4	1.0303							1		4	1	69
11	1.2561											126
18	1.4450	.25										52
25	1.6661											34
July 2	1.9060											51
9	2.1434	.50										10
16	2.3580	1.65										26
23	2.5782											25
30	2.8030											8
Aug. 6	3.0311											6

[1]Thermograph probe among bolls was buried in blown mica in cage.

TABLE 3.--*Pink bollworm moth emergence with temperature and moisture data 1973-74*

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 10-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 15	Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	
			Boll collection of September 5, 1973									
Sept. 24	0.6056		4	37								
Oct. 1	.7775		6	222								
8	.9437		7	20	55							
15	1.0467		5		12							
22	1.1845		5		1	1						
29	1.2886		6									
Nov. 5	1.3668		7									
12	1.4363		6									
19	1.4735		101									
26	1.4735		65									
Dec.	1.4903	1.5546	108-8									
Jan.	1.4927	1.5546	64-8									
Feb.	1.5142	1.5548	33-5									
Mar.	1.7165	1.5960	33-5									
Apr.	2.1676	1.7806	7-3									
May 1-27	2.8406	2.3659	3-1									
June 3	3.0506	2.5690	2		1							
10	3.2711	2.7868	3	2			1					3
17	3.5088	3.0188	3	1	1							1
24	3.7488	3.2565	12									
July 1	3.9903	3.4962	4									
8	4.2277	3.7345	27	1								
15		3.9652	4									1
22		4.1866	176									4
29		4.4172	130									2

See footnotes at end of table.

TABLE 3.--*Pink bollworm moth emergence with temperature and moisture data 1973-74*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 10-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 15	Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	
Boll collection of September 15, 1973												
Oct. 8	0.6209		7		110							
15	.7239		5		40							
22	.8617		5			6	3					
29	.9658		6			3	3					
Nov. 5	1.0440		7				1					
12	1.1135		6				1					
19	1.1507		101									
26	1.1507		65									
Dec.	1.1675	1.2318	108-8									
Jan.	1.1699	1.2318	64-8									
Feb.	1.1914	1.2320	33-5									
Mar.	1.3937	1.2732	33-5									
Apr.	1.8448	1.4578	7-3									
May 6	1.9749	1.5564	3-1									
13	2.1656	1.7151	3-1									
20	2.3396	1.8762	3-1									
27	2.5178	2.0431	3-1									
June 3	2.7278	2.2462	2		4	1	2					
10		2.4640	3									1
17		2.6960	3								1	
24		2.9337	12									
July 1		3.1734	4									
8		3.4117	27									
15		3.6424	4									
22		3.8638	176									20
29		4.0944	130									5

TABLE 3.--*Pink bollworm moth emergence with temperature and moisture data 1973-74*--Continued

Week ending	Accumulated RUD: Soil[1]	Accumulated RUD: Bolls[2]	Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 10-day period ending--: Sept. 15	Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	Number of moths emerging from bolls
			Boll collection of September 15, 1973									
Oct. 15	0.4105		5			11						
22	.5483		5			30						
29	.6524		6			3						
Nov.	.8388		101-6									
Dec.	.8541	0.9199	108-8									
Jan.	.8565	.9199	64-8									
Feb.	.8780	.9201	33-5									
Mar.	1.0803	.9613	33-5									
Apr.	1.5314	1.1459	7-3									
May	2.3280	1.8507	3-1									
June 3	2.4144	1.9343	2			4		1				
10	2.6349	2.1521	3			1						1
17	2.8726	2.3841	3			2						
24		2.6218	12									
July 1		2.8615	4									
8		3.0998	27									1
15		3.3305	4									
22		3.5519	176									
29		3.7825	130									
			Boll collection of October 5, 1973									
Oct. 29	.4162		7-5				1					N
Nov.	.6026		101-6									
Dec.	.6179		108-8									O
Jan.	.6203		64-8									
Feb.	.6418		33-5									N
Mar.	.8441		33-5									
Apr.	1.2952		7-3									E

TABLE 3.--*Pink bollworm moth emergence with temperature and moisture data 1973-74*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 10-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 15	Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	
Boll collection of October 5, 1973--Continued												
May 6	1.4253		3-1				2					N
13	1.6160		3-1									
20	1.7900		3-1									O
27	1.9682		3-1									
June 3	2.1782		2				2					N
10	2.3987		3				2	1				
												E
Boll collection of October 15, 1973												
NO EMERGENCE												
Boll collection of October 25, 1973												
Oct.		0.0697	7-5									
Nov.		.2403	101-6									
Dec.		.3214	108-8									
Jan.		.3214	64-8									
Feb.		.3216	33-5									
Mar.		.3628	33-5									
Apr.		.5474	7-3									
May		1.2522	3-1									
June 3		1.3358	2									
10		1.5536	3									2
17		1.7856	3									3
24		2.0233	12									1
July 1		2.2630	4									5
8		2.5013	27									7
15		2.7320	4									0
22		2.9534	176									2
29		3.1840	130									4
Aug. 5		3.4148	187									1

TABLE 3.--*Pink bollworm moth emergence with temperature and moisture data 1973-74*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 10-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 15	Sept. 25	Oct. 5	Oct. 15	Oct. 25	Nov. 4	Nov. 14	Nov. 24	
			Boll collection of November 4, 1973									
Nov.	0.1185		101-6									
Dec.	.1996		108-8									
Jan.	.1996		64-8									
Feb.	.1998		33-5									
Mar.	.2410		33-5									
Apr.	.4256		7-3									
May 6	.5242		3-1									1
13	.6829		3-1									
20	.8440		3-1									
27	1.0109		3-1									
June 3	1.2140		2									1
10	1.4318		3									0
17	1.6638		3									2
24	1.9015		12									0
July 1	2.1412		4									1
8	2.3795		27									2
15	2.4917		4									6
22	2.8316		176									13
29	3.0622		130									6

[1]Thermograph probe in blown mica substrate surrounding carton cages.
[2]Thermograph probe among bolls buried in blown mica in cage.
[3]Blown mica will retain water in excess of 3 times its own weight.

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	
Boll collection of September 5, 1974												
Oct. 1	0.6511		223	24								
8	.8166		393	50	2							
15	.8958		485	3	17							
22	.9114		193		4							
29	1.0229		66		3							
Nov. 5	1.0229		156		1							
12	1.0235		193									
19	1.0270		262									
26	1.0296	1.0296	153			2						
Dec. 3	1.0296	1.0296	155									
10	1.0296	1.0296	44									
17	1.0296	1.0296	88									
24	1.0296	1.0296	178									
31	1.0296	1.0296	185									
Jan.	1.0296	1.0296	19-160									
Feb.	1.0314	1.0296	15- 83									
Mar.	1.0722	1.0323	49-149									
Apr. 15	1.0884	1.0328	62-105									
22	1.1226	1.0400	82									
29	1.1916	1.0660	31									
May 6	1.2823	1.1096	64									
13	1.4215	1.1955	64									
20	1.6093	1.3593	5									
27	1.7658	1.4934	4									
June 3	1.9760	1.6910	7					1				1
10	2.2068	1.9123	5									2
17	2.4447	2.1443	3									0
24	2.6694	2.3709	2	1								5

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	
			Boll collection of September 5, 1974--Continued									
July 1	2.9045	2.6020	2	1								0
8		2.8369	4									0
15		3.0724	5									0
22		3.3072	4									2
29		3.5422	33									3
Aug. 5		3.7444	5									0
12		3.9828	9									0
19		4.2171	6									1
			Boll collection of September 19, 1974									
Oct. 1	0.2417		223									
8	.4022		393		10							
15	.4864		485		127	2						
22	.5820		193		41	0						
29	.6135		66		12	4	2					
Nov. 5	.6135		156		2	3	1					
12	.6141		193		1	5	0					
19	.6176		262			2	1	1				
26	.6202	.6202	153			1						
Dec. 3	.6202	.6202	155			3						
10	.6202	.6202	44			0						
17	.6202	.6202	88			0						
24	.6202	.6202	178			0						
31	.6202	.6202	185			1						
Jan.	.6202	.6202	19-160									
Feb.	.6220	.6202	15- 83									
Mar.	.6628	.6229	49-149									
Apr. 15	.6790	.6234	62-105									
22	.7132	.6306	82									1
29	.7822	.6566	31									0

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*--Continued

Week ending	Accumulated RUD Soil[1]	Accumulated RUD Bolls[2]	Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending-- Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	Number of moths emerging from bolls
Boll collection of September 19, 1974--Continued												
May 6	0.8729	0.7002	64									0
13	1.0121	.7861	64									1
20	1.1999	.9497	5									0
27	1.3564	1.0840	4		3							0
June 3	1.5666	1.2816	7		1							3
10	1.7974	1.5029	5		5							4
17	2.0353	1.7349	3		1							2
24	2.2600	1.9615	2					1				4
July 1	2.4951	2.1926	2			1						3
8		2.4275	4									0
15		2.6630	5									0
22		2.8978	4									5
29		3.1328	33									21
Aug. 5		3.3350	5									2
12		3.5734	9									5
Boll collection of October 3, 1974												
Oct. 29	.3200		66			57						
Nov. 5	.3200		156			21						
12	.3206		193			11	1					
19	.3241		262			49	2	1				
26	.3267	.3267	153			16	20	1				
Dec. 3	.3267	.3267	155			3	18					
10	.3267	.3267	44			0	31					
17	.3267	.3267	88			0	0					
24	.3267	.3267	178			1	27			1		
31	.3267	.3267	185									
Jan.	.3267	.3267	19-160									

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	
			Boll collection of October 3, 1974--Continued									
Feb.	0.3285	0.3267	15- 83									
Mar.	.3693	.3294	49-149									
Apr. 15	.3855	.3299	62-105									
22	.4197	.3371	82									
29	.4887	.3631	31									
May 6	.5794	.4067	64			1	1					
13	.7168	.4926	64			1	1		1			3
20	.9064	.6562	5			0	1					0
27	1.0629	.7905	4			1	2					13
June 3	1.2731	.9881	7			7						59
10	1.5039	1.2094	5			0						19
17	1.7418	1.4144	3			0						4
24	1.9665	1.6680	2			0						13
July 1	2.2016	1.8991	2			3						3
8	2.4405	2.1340	4			0						0
15	2.6777	2.3695	5			1						1
22		2.6043	4									6
29		2.8393	33									30
Aug. 5		3.0415	5									5
12		3.2799	9									13
19		3.5142	6									0
26		3.7466	5									3
Sept. 2		3.9797	79									0
9		4.1935	60									1
16		4.3690	30									1
			Boll collection of October 17, 1974									
Nov. 26	.1100	.1100	153				6					
Dec. 3	.1100	.1100	155				5					

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	
			Boll collection of October 17, 1974--Continued									
Dec. 10	0.1100	0.1100	44				12					
17	.1100	.1100	88				0					
24	.1100	.1100	178				11					
31	.1100	.1100	185				4					
Jan.	.1100	.1100	19-160									
Feb.	.1118	.1100	15- 83									
Mar.	.1526	.1127	49-149									
Apr. 15	.1688	.1132	62-105									
22	.2030	.1204	82									
29	.2720	.1464	31									2
May 6	.3627	.1900	64									0
13	.5019	.2759	64				2	14	1		1	3
20	.6897	.4395	5				10	0	0			5
27	.8462	.5738	4				5	1	0			17
June 3	1.0564	.7714	7				5	0	1			88
10	1.2872	.9927	5				14	1				90
17	1.5251	1.2247	3				24	0				3
24	1.7498	1.4513	2				9	4				15
July 1	1.9849	1.6824	2				6	1				27
8	2.2238	1.9173	4				0					0
15	2.4610	2.1528	5				0					0
22	2.6980	2.3876	4				0					18
29	2.9348	2.6226	33				1					50
Aug. 5	3.1716	2.8248	5				0					2
12	3.4118	3.0632	9				1					5
19		3.2975	6									0
26		3.5299	5									0
Sept. 2		3.7630	79									0
9		3.9768	60									2

TABLE 4.--*Pink bollworm moth emergence with temperature and moisture data 1974-75*--Continued

Week ending	Accumulated RUD		Moisture[3] percentage of dry weight	Number of moths emerging from free cocoons initiating in the 14-day period ending--								Number of moths emerging from bolls
	Soil[1]	Bolls[2]		Sept. 19	Oct. 3	Oct. 17	Oct. 31	Nov. 14	Nov. 28	Dec. 12	Dec. 26	
Boll collection of October 31, 1974--Continued												
Nov.	0.0049	0.0049	153-262									
Dec.	.0049	.0049	44-185									
Jan.	.0049	.0049	19-160									
Feb.	.0085	.0049	15- 83									
Mar.	.0493	.0076	49-149									
Apr. 15	.0655	.0081	62-105									
22	.0997	.0153	82									
29	.1687	.0413	31									
May 6	.2594	.0849	64									
13	.3986	.1708	64						1			15
20	.5864	.3344	5						1			4
27	.7429	.4687	4					1	1			28
June 3	.9531	.6663	7					19	9	2		62
10	1.1839	.8876	5					19	5	4		55
17	1.4218	1.1196	3					0	2			28
24	1.6465	1.3462	2					15	8			32
July 1	1.8816	1.5773	2					6	2			20
8	2.1205	1.8122	4					0				0
15	2.3577	2.0477	5					2				1
22	2.5947	2.2815	4					2				30
29	2.8315	2.5175	33					1				70
Aug. 5		2.7197	5					1				8
12		2.9581	9									12
19		3.1924	6									0
26		3.4248	5									1

[1]Thermograph probe in blown mica substrate surrounding carton cages.
[2]Thermograph probe among bolls buried in blown mica in cage.
[3]Blown mica will retain water in excess of 3 times its own weight.

TABLE 5.--*Emergence of overwintering pink bollworm adults from bolls maintained under naturally occurring and modified regimens, Tucson, Ariz., 1975-76*

Week of--		1975-76 rainfall	Substrate moisture	Accumulated RUD	Adults emerged	Moisture: Irrigation	Moisture: Substrate moisture	Accumulated RUD	Adults emerged
		Inch	*Percent*		*Number*	*Inch*	*Percent*		*Number*
					Field data				
		Actual 1975-76 conditions							
Oct.	31			0.5813					
Nov.		0.08	6- 3	1.0345					
Dec.		.66	50- 5	1.0520					
Jan.		.04	38- 8	1.0752	53[1]				
Feb.	4	.26	9	1.0829					
	11		8	1.1116					
	18		20	1.1518					
	25		4	1.1847					
Mar.	3		4	1.2377					
	10	.75	19	1.2541					
	17		6	1.3047					
	24		3	1.3928					
	31		5	1.4643	1				
Apr.	7		6	1.5613	4				
	14		4	1.6717	1				
	21	.86	5	1.7384	2				
	28		15	1.8902	7				
May	5	.03	6	2.0519	14				
	12		10	2.2153	21				
	19		6	2.4237	3				
	26		3	2.6233	33				
June	2		3	2.8381	18				
	9		3	3.0659	32				
	16		2	3.2852	5				
	23		3	3.5228	2				
	30	.04	3	3.7609	3				
July	7		2	4.0025	1				
	14	.97	68	4.2427					
	21	.51	37	4.4783	1				
	28	.16	30	4.7133					
Aug.	4		34	4.9438					
	11	.41	11	5.1735					
	18	.01	6	5.4008					
	25	.56	14	5.6353					
			Heated				*Shaded*		
Oct.	31			.6063				0.5548	
Nov.		.08	6- 3	1.2910			6-3	.8280	
Dec.		.66	59- 5	1.8030		0.03	10-5	.8286	
Jan.		.04	70-13	2.2739	35[1]	.66	81-6	.8286	6[1]

TABLE 5.--*Emergence of overwintering pink bollworm adults from bolls maintained under naturally occurring and modified regimens, Tucson, Ariz., 1975-76*--Continued

Week of--	1975-76 rainfall	Substrate moisture	Accumulated RUD	Adults emerged	Moisture: Irrigation	Moisture: Substrate moisture	Accumulated RUD	Adults emerged
	Inch	*Percent*		*Number*	*Inch*	*Percent*		*Number*
	Heated--Continued					*Shaded*--Continued		
Feb. 4	0.26	7	2.3549		0.04	8	0.8286	
11		5	2.4725	2		18	.8350	
18		4	2.5910	2	.26	5	.8350	
25		2	2.7077			4	.8350	
Mar. 3		4	2.8415			9	.8396	
10	.75	25	2.9346		.75	14	.8396	
17		5	3.0960	4		30	.8396	
24		3	3.2602	17		25	.8528	3
31		3	3.4134	9		8	.8620	
Apr. 7		3	3.5978	7		4	.8854	
14		3	3.7820	13		4	.9413	
21	.86	40	3.9298	9		5	.9685	
28		20	4.1152	8	.85	39	1.0591	1
May 5	.03	4	4.2924	2		19	1.1826	4
12		3	4.4827	3	.03	28	1.3149	3
19		4	4.7001	1		28	1.5107	15
26		3	4.9185	6		32	1.6883	0
June 6		2	5.1426	7		25	1.8797	169
9		2	5.3734	12		20	2.0877	93
16		2	5.6014	3		23	2.2898	77
23		3	5.8403	1		6	2.5150	48
30	.04	2	6.0796	1	.04	3	2.7419	40
July 7		2	6.3210	0		2	2.9781	13
14	.97	72	6.5610	1	.97	74	3.2156	6
21	.51	95	6.7966	1	.51	50	3.4512	2
28	.16	22	7.0316		.16	5	3.6862	1
Aug. 4		7	7.2621			6	3.9167	
11	.41	20	7.4918		.41	7	4.1440	
18	.01	5	7.7191		.01	4	4.3713	
25	.56	20	7.9536		.56	36	4.6058	1
		Dry				*Wet*		
Oct. 31			0.5808				0.6044	
Nov.	.08	6-3	1.1505		1.00	86-56	1.0637	
Dec.	.66	9-4	1.2380		1.00	229-42	1.0829	
Jan.	.04	5-4	1.2991	101[1]	1.00	224-65	1.1140	10[1]
Feb. 4	.26	4	1.3182		1.00	247	1.2247	
11		5	1.3635			230	1.1534	
18		4	1.4120			72	1.2006	
25		5	1.4578			135	1.2420	

TABLE 5.--*Emergence of overwintering pink bollworm adults from bolls maintained under naturally occurring and modified regimens, Tucson, Ariz., 1975-76*--Continued

Week of--	1975-76 rainfall	Substrate moisture	Accumulated RUD	Adults emerged	Moisture: Irrigation	Moisture: Substrate moisture	Moisture: Accumulated RUD	Moisture: Adults emerged
	Inch	*Percent*		*Number*	*Inch*	*Percent*		*Number*
	Dry--Continued					*Wet*--Continued		
Mar. 3		4	1.5431		1.00	94	1.3317	
10	0.75	6	1.5719			119	1.3524	
17		3	1.6250	2		74	1.4090	
24		4	1.7193	6		8	1.5094	
31		5	1.7965		1.00	165	1.5894	2
Apr. 7		4	1.9128	9		90	1.6995	1
14		3	2.0530	3		138	1.8597	1
21	.86	4	2.1279	2		121	1.9428	3
28		3	2.2927	5		85	2.1115	14
May 5	.03	4	2.4788	5	1.00	145	2.3134	10
12		3	2.6620	7		23	2.4941	4
19		4	2.8838	0		18	2.7222	14
26		3	3.0943	13	1.00	126	2.9450	0
June 2		3	3.3198	0		110	3.1699	18
9		2	3.5551	14		125	3.4045	4
16		3	3.7815	7		88	3.6413	2
23		3	4.0207	1		70	3.8818	1
30	.04	3	4.2596	3		71	4.1228	1
July 7		2	4.5008			5	4.3634	
14	.97	64	4.7402	3		104	4.6013	
21	.51	53	4.9758			84	4.8369	
28	.16	42	5.2108			18	5.0719	
Aug. 4		39	5.4413			23	5.3024	
11	.41	5	5.6710			15	5.5321	1
18	.01	7	5.8983			13	5.7595	
25	.56	26	6.1328			24	5.9939	
			Insectary data					
	Dry						*Wet*	
Nov. 5		11	0.3131	2		288	0.2657	1
12		6	.3938	22		265	.3168	48
19		7	.4462	196		224	.3237	161
26		4	.4605	78		268	.3252	56
Dec. 3		7	.4779	62		271	.3291	62
10		12	.5113	70		484	.3315	37
17		8	.5217	31		394	.3319	33
24		10	.5315	9		404	.3323	31
31		11	.5315	10		350	.3323	5

TABLE 5.--*Emergence of overwintering pink bollworm adults from bolls maintained under naturally occurring and modified regimens, Tucson, Ariz., 1975-76*--Continued

Week off--	1975-76 rainfall	Substrate moisture	Accumulated RUD	Adults emerged	Moisture: Irrigation	Moisture: Substrate moisture	Moisture: Accumulated RUD	Moisture: Adults emerged
	Inch	*Percent*		*Number*	*Inch*	*Percent*		*Number*
	Dry--Continued					*Wet*--Continued		
Jan. 7		8	0.5315	11		545	.3323	4
14		9	.5413	12		483	.3326	1
21		3	.5692	8		451	.3368	0
28		6	.5797	7		443	.3368	
Feb. 4		2	.6158	1		452	.3388	
11		7	.6326	0		408	.3388	
18		9	.6482	2		436	.3388	
25		4	.6832	2		414	.3388	
Mar. 3		7	.7390	2		293	.3388	
10		5	.7433	0		284	.3388	
17		4	.7774	1		290	.3388	2
24		3	.8576	17		219	.3450	9
31		3	.9126	8		187	.3466	10
Apr. 7		4	.9934	33		181	.3529	16
14		6	1.0863	27		249	.3615	6
21		3	1.1279	35		244	.3615	11
28		4	1.2606	149		179	.3706	4
May 5		5	1.3962	192		152	.3918	71
12		3	1.5244	253		128	.4149	72
19			1.7096	520			.4602	107
26		2	1.8685	857		259	.4666	121
June 2		2	2.0483	811		234	.4835	71
9		3	2.2504	1161		286	.4891	57
16		3	2.4345	677		162	Equipment	13
23		3	2.6576	573		247	malfunction	2
30		3	2.8830	475		129		1
July 7		2	3.1206	212		303		1
14		3	3.3500	216		214		1
21		9	3.5724	85		347		0
28		7	3.7894	311		235		4
Aug. 4		8	3.9957	76		310		0
11		5	4.2261	13		249		0
18		4	4.4489	1		198		0
25		2	4.6800	16		156		0
Sept. 1		2	4.9091	42		159		0
8		4	5.1013	20		196		0
15		4	5.2942	11		148		0
22		4	5.4818	7		201		0
29		4	5.6299	1		239		0

[1]Accumulated emergence after installation to end of January.

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*

Week of--	Emergence[1] of *Heliothis zea*								
	Insects originating in second 2 weeks of July								
	July 20[2] July 29[3]	July 20 Aug. 3	July 20 Aug. 6	July 21 July 29	July 22 Aug. 3	July 22 Aug. 6	July 27 Aug. 4	July 27 Aug. 6	July 29 Aug. 9
Aug. 10	5(.5160)			2(.5834)					
	11(.5834)								
17	3(.7710)	4(.6181)	1(.7142)	8(.7710)	1(.6181)		1(.5838)		
			1(.9140)	2(.8367)	3(.7178)		3(.6820)		
24					3(.8295)		3(.7937)	18(.7142)	42(.5963)
							1(.9935)	7(.9140)	
31									8(.8177)
Sept. 7						1(1.3091)			
Nov. 1						1(2.4157)			
	Insects originating in August								
	Aug. 5 Aug. 17	Aug. 12 Aug. 23	Aug. 17 Aug. 27	Aug. 19 Aug. 30	Aug. 23 Sept. 1	Aug. 26 Sept. 7	Aug. 31 Sept. 10		
Aug. 31	5(.5324)								
Sept. 7	5(.8652)	43(.6659)							
		4(.8318)	31(.6811)						
14			3(.7603)	34(.6398)	2(.5779)				
				2(.7238)	20(.6619)				
21					9(.7662)	3(.5137)			
						9(.5825)			
28						5(.7052)	23(.5842)		
						1(.7678)	17(.6468)		
Apr. 4		1(3.1325)							

See footnotes at end of table.

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Heliothis zea*					
	Insects originating in first 2 weeks of September					
	Sept. 2[2] Sept. 13[3]	Sept. 7 Sept. 20	Sept. 9 Sept. 22	Sept. 13 Sept. 24		
Sept. 28	1(.4950)					
	12(.5679)					
Oct. 5	1(.6590)					
12		7(.5670)	1(.5186)			
		2(.5918)	2(.5434)			
		6(.6180)	6(.5696)			
19		3(.6781)	3(.6297)	4(.5837)		
26				8(.6233)		
				2(.6451)		
Nov. 2		1(.7829)	1(.7345)	2(.6885)		
Mar. 28				2(1.9644)		
Apr. 4				1(2.0190)		
	Insects originating in second 2 weeks of September					
	Sept. 14 Sept. 29	Sept. 16 Sept. 29	Sept. 21 Oct. 6	Sept. 24 Oct. 12	Sept. 28 Oct. 13	Sept. 30 Oct. 19
Oct. 19	1(.4362)					
26	1(.4899)	2(.4758)				
	1(.4901)	3(.4976)				
Nov. 2	1(.5138)	1(.5138)				
	1(.5410)	6(.5410)				
	1(.5721)	3(.5721)				
9		1(.6115)	4(.4647)			
			5(.4948)			
23			7(.5151)			
30			6(.5501)			
Dec. 21				1(.4431)		

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Heliothis zea*						
	Insects originating in second 2 weeks of September--Continued						
	Sept. 14[2] Sept. 29[3]	Sept. 16 Sept. 29	Sept. 21 Oct. 6	Sept. 24 Oct. 12	Sept. 28 Oct. 13	Sept. 30 Oct. 19	
Mar. 28					3(1.2174)		
Apr. 4	1(1.6843)		1(1.5375)	3(1.3834)	5(1.3592)	4(1.2866)	
	2(1.7522)	5(1.7552)	3(1.6056)	7(1.4513)	15(1.4271)	9(1.3545)	
	1(1.8169)	7(1.8169)	2(1.6701)	5(1.5160)	7(1.4868)	6(1.4192)	
11		2(1.8715)		3(1.5706)	2(1.5464)	1(1.4738)	
		2(1.8880)	1(1.7412)				
		2(1.9376)	1(1.7908)	1(1.6367)	1(1.6125)		
18	1(1.9892)	1(1.9653)	1(1.8424)		1(1.6641)		
	1(2.0535)						
25		1(2.1076)					
May 2					1(1.9729)		
	Insects originating in October						
	Oct. 5 Oct. 26	Oct. 7 Nov. 2	Oct. 12 Nov. 9	Oct. 14 Nov. 15	Oct. 21 Dec. 3	Oct. 26 Dec. 29	Oct. 28 Jan. 6
Mar. 21	1(.8328)		5(.9159)		3(.7992)		
	1(1.1235)		2(1.0097)		3(.8930)	1(.7957)	1(.7456)
28	3(1.1465)	3(1.1119)					
Apr. 4	10(1.2157)	9(1.1811)	3(1.1019)	2(1.0427)	3(.9852)		
	5(1.2836)	4(1.2490)	4(1.1698)		3(1.0531)		
		1(1.3137)	3(1.2345)				
11		1(1.3683)	1(1.3056)				

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--						
	Emergence[1] of *Heliothis zea*					
	Insects originating in November					
	Nov. 2[2] Jan. 11[3]	Nov. 9 Jan. 27	Nov. 11 Feb. 14	Nov. 30 Feb. 29		
Mar. 14	1(.6879)					
21		1(.6834)				
		1(.7354)	5(.6202)			
Apr. 4		1(.7830)		4(.5942)		
			1(.8327)	2(.6621)		
	Insects originating in December and January					
	Dec. 7 Feb. 29	Dec. 14 Feb. 29	Dec. 21 Feb. 29	Dec. 28 Feb. 29	Jan. 6 Feb. 29	Jan. 13 Feb. 29
Mar. 21			7(.5020)			
28	2(.5250)	2(.5250)	10(.5250)		2(.5250)	
Apr. 4	10(.5942)	5(.5942)	10(.5942)	5(.5942)	7(.5942)	3(.5942)
	5(.6621)	5(.6621)	14(.6621)	17(.6621)	17(.6621)	8(.6621)
	1(.7268)		2(.7268)	2(.7268)	3(.7268)	16(.7268)
11						4(.7814)
	Emergence[1] of *Heliothis virescens*					
	Insects originating in second 2 weeks of July					
	July 20 July 29	July 22 July 31	July 27 Aug. 4	July 27 Aug. 6	July 29 Aug. 6	
Aug. 10	19(.4924)					
	15(.5566)					
17	5(.7353)	34(.6523)	9(.5560)			
24			45(.7574)	4(.6807)	49(.6807)	
31				2(.8701)	1(.8701)	

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Heliothis virescens*								
	Insects originating in August								
	Aug. 3[2] Aug. 12[3]	Aug. 12 Aug. 23	Aug. 17 Aug. 27	Aug. 19 Aug. 31	Aug. 23 Sept. 2	Aug. 26 Sept. 7	Aug. 31 Sept. 10		
Aug. 31	37(.6629)								
	3(.7839)								
Sept. 7		36(.6336)							
		5(.7924)							
14			29(.6489)	11(.5723)	2(.4863)				
			9(.7244)	9(.6498)	5(.5638)				
21				4(.7497)	12(.6637)	5(.4882)			
						11(.5547)			
28						4(.6717)	8(.5563)		
Oct. 5							15(.6894)		
	Insects originating in September								
	Sept. 2 Sept. 13	Sept. 9 Sept. 22	Sept. 13 Sept. 24	Sept. 14 Sept. 29	Sept. 16 Sept. 29	Sept. 21 Oct. 6	Sept. 24 Oct. 12	Sept. 28 Oct. 13	Sept. 30 Oct. 19
Oct. 5	17(.5695)								
	12(.6267)								
	2(.6480)								
12	2(.7721)	1(.5460)	1(.5201)						
19		2(.6038)	1(.5595)						
26			2(.6119)		2(.4713)				
Nov. 2				2(.5369)	5(.5369)				
9				4(.6050)	1(.6050)	2(.4655)			
16				1(.6124)		1(.4729)			
30					1(.6596)	3(.5201)			
Dec. 7						1(.5236)			
14							1(.3838)		
Jan. 4							1(.4242)		

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Heliothis virescens*								
	Insect originating in September--Continued								
	Sept. 2[2] Sept. 13[3]	Sept. 9 Sept. 22	Sept. 13 Sept. 24	Sept. 14 Sept. 29	Sept. 16 Sept. 29	Sept. 21 Oct. 6	Sept. 24 Oct. 12	Sept. 28 Oct. 13	Sept. 30 Oct. 19
Mar. 14							1(1.0959)	3(1.0723)	
21						1(1.2882)	1(1.1392)	1(1.1156)	
				1(1.4673)	1(1.4673)	6(1.3278)		2(1.1552)	3(1.0850)
					1(1.5174)	4(1.3779)	1(1.2289)	5(1.2053)	1(1.1351)
28				1(1.5398)	2(1.5398)	1(1.4003)			
Apr. 4			1(1.7643)	4(1.6057)	1(1.6057)	5(1.4662)	1(1.3172)	8(1.2936)	3(1.2234)
			2(1.8114)	2(1.6708)	2(1.6708)	3(1.5313)		2(1.3587)	4(1.2885)
								2(1.4208)	1(1.3506)
11								1(1.4736)	
	Insects originating in October								
	Oct. 7 Nov. 3	Oct. 12 Nov. 8	Oct. 21 Dec. 3	Oct. 26 Dec. 13	Oct. 28 Dec. 29				
Mar. 14		1(.7594)							
21	2(.9827)		1(.8053)		4(.7606)				
Apr. 11				1(1.1220)					
	Insects originating in November and December								
	Nov. 2 Jan. 6	Nov. 4 Jan. 11	Nov. 11 Jan. 27	Nov. 18 Feb. 14	Nov. 26 Feb. 29	Dec. 6 Feb. 29	Dec. 13 Feb. 29	Dec. 20 Feb. 29	
Mar. 21	4(.8020)	3(.9729)							
		1(1.0230)	4(.7079)	1(.6444)					
28			1(.7303)	1(.6668)					

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--								
	Emergence[1] of *Heliothis virescens*							
	Insects originating in November and December--Continued							
	Nov. 2[2] Jan. 6[3]	Nov. 4 Jan.11	Nov. 11 Jan. 27	Nov. 18 Feb. 14	Nov. 26 Feb. 29	Dec. 6 Feb. 29	Dec. 13 Feb. 29	Dec. 20 Feb. 29
Apr. 4			5(.8022)	8(.7327)	3(.6338)		1(.6338)	4(.6338)
			1(.8613)	1(.7978)	7(.6959)	1(.6959)	2(.6959)	11(.6959)
11					1(.7487)		2(.7487)	
							1(.7641)	2(.7487)
May 2					1(1.3201)			
	Emergence[1] of *Spodoptera exigua*							
	Insects originating in last 2 weeks of July							
	July 19 July 27	July 22 July 28	July 22 July 29	July 27 Aug. 3	July 27 Aug. 5	July 29 Aug. 5		
July 27	16(.4015)							
Aug. 3	2(.5837)	6(.3988)						
	5(.9145)	19(.5128)	5(.4425)					
10		3(.8436)	2(.7733)	27(.4448)				
				13(.5413)				
17					3(.6522)	40(.6562)		
						22(.7066)		
	Insect originating in first 2 weeks of August							
	Aug. 3 Aug. 10	Aug. 3 Aug. 11	Aug. 5 Aug. 13	Aug. 10 Aug. 20	Aug. 12 Aug. 20			
Aug. 17	42(.5153)							
24	2(.8282)	9(.7847)	53(.6882)	45(.5508)	62(.5508)			
31				2(.8001)	1(.8001)			
Sept. 7				2(1.0190)				

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Spodoptera exigua*				
	Insects originating in second 2 weeks of August				
	Aug. 17[2] Aug. 27[3]	Aug. 19 Aug. 31	Aug. 23 Sept. 2	Aug. 26 Sept. 3	
Sept. 7	26(.7080)				
14		19(.8969)	18(.7627)	41(.7077)	
			3(.8892)	2(.7710)	
	Insects originating in first 2 weeks of September				
	Sept. 2 Sept. 10	Sept. 4 Sept. 14	Sept. 9 Sept. 16	Sept. 13 Sept. 22	Sept. 14 Sept. 24
Sept. 14	4(.4336)				
21	35(.5849)	19(.4375)			
		6(.5708)			
28			34(.4922)		
Oct. 5			1(.6903)	19(.4431)	3(.3769)
				6(.5311)	24(.4649)
					3(.4963)
	Insects originating in second 2 weeks of September				
	Sept. 16 Sept. 28	Sept. 21 Oct. 5	Sept. 23 Oct. 5	Sept. 28 Oct. 12	Sept. 30 Oct. 12
Oct. 12	16(.5018)	9(.3760)	5(.3760)		
	1(.5741)	14(.4007)	24(.4007)		
19			1(.4581)		
Nov. 2				11(.3312)	
				10(.3750)	12(.3750)
9				4(.4491)	8(.4491)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Spodoptera exigua*				
	Insects originating in October				
	Oct. 5[2] Oct. 18[3]	Oct. 7 Oct. 20	Oct. 12 Nov. 5	Oct. 14 Nov. 8	Oct. 27 Dec. 3
Nov. 16	4(.3525)				
23	14(.3914)	15(.3717)			
30	6(.4141)	11(.3944)			
Dec. 14		5(.3993)			
21		2(.4491)			
Jan. 11			5(.2928)		
18			5(.3514)	2(.3418)	
Feb. 1				1(.3731)	
29					1(.6820)
	Insects originating in November				
	Nov. 4 Dec. 29	Nov. 18 Feb. 14			
Feb. 29	7(.5810)				
Mar. 7		3(.4553)			
		3(.4896)			
		6(.5801)			
14		1(.6334)			

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--									
	Emergence[1] of *Spodoptera exigua*								
	Insects originating in December and January								
	Dec. 9[2] Feb. 28[3]	Dec. 21 Feb. 28	Dec. 30 Feb. 28	Jan. 6 Feb. 28	Jan. 13 Feb. 28	Jan. 20 Feb. 28			
Mar. 14	7(.5457)	4(.4125)	2(.4125)	2(.4125)	21(.4125)				
		4(.5457)	20(.5457)	8(.5457)	15(.5457)	22(.4832)			
21	1(.7416)	3(.6104)	1(.6104)	1(.6104)		1(.5479)			
						2(.6061)			
						3(.6791)			
	Emergence[1] of *Trichoplusia ni*								
	Insects originating in second 2 weeks of July								
	July 20 July 29	July 23 Aug. 3	July 27 Aug. 4	July 27 Aug. 5	July 27 Aug. 9	July 29 Aug. 6	July 29 Aug. 11		
Aug. 3	39(.6251)								
10		3(.7237)							
17	1(1.0749)	16(.7755)	4(.7254)	24(.7616)	2(.5427)	63(.7066)			
	1(1.1678)								
31				1(1.3370)	2(1.1181)	2(1.2820)	7(1.0268)		
	Insects originating in August								
	Aug. 3 Aug. 13	Aug. 3 Aug. 20	Aug. 5 Aug. 17	Aug. 5 Aug. 17	Aug. 10 Aug. 23	Aug. 12 Aug. 23	Aug. 17 Aug. 27	Aug. 19 Aug. 31	Aug. 31 Sept. 10
Aug. 24	30(.6011)								
31	15(.9310)	4(.5754)	42(.7165)	7(.5754)	11(.4335)				
		1(.7537)		8(.7537)	15(.6118)	29(.7537)			
Sept. 7					5(.9853)	3(.9853)	24(.7746)		
14								45(.7788)	8(.5475)
									10(.6508)
									3(.7814)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Trichoplusia ni*					
	Insects originating in first 2 weeks of September					
	Sept. 2[2] Sept. 13[3]	Sept. 7 Sept. 16	Sept. 8 Sept. 22	Sept. 9 Sept. 20	Sept. 13 Sept. 24	Sept. 14 Sept. 28
Sept. 21	14(.4774)					
28	19(.6525)	4(.4899)				
	1(.7706)	15(.6583)				
			11(.5425)	10(.5278)		
Oct. 5				8(.6476)	1(.4737)	
12			7(.7282)			13(.6594)
	Insects originating in second 2 weeks of September					
	Sept. 14 Sept. 28	Sept. 16 Sept. 29	Sept. 21 Oct. 5	Sept. 23 Oct. 7	Sept. 28 Oct. 12	Sept. 30 Oct. 14
Oct. 12	15(.5202)	16(.4834)				
	8(.5954)	13(.5586)	3(.4160)			
19			17(.4801)	5(.3935)		
26			4(.6104)	17(.5238)		
			1(.6331)	4(.5465)		
Nov. 2					4(.4417)	
					6(.4893)	
9					6(.5647)	10(.4922)
						4(.5214)
16						2(.5346)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Trichoplusia ni*				
	Insects originating in October and November				
	Oct. 52 Oct. 18[3]	Oct. 7 Oct. 26	Oct. 14 Oct. 9	Nov. 18 Feb. 15	
Nov. 23	2(.4871)				
	2(.5154)				
30	3(.5489)				
	1(.5551)	5(.4293)			
Dec. 14	1(.5619)	1(.4423)			
21		2(.4588)			
Jan. 11			1(.3393)		
18			2(.4053)		
25			1(.4670)		
Mar. 7				5(.4970)	
14				2(.6435)	
	Insects originating in December				
	Dec. 14 Feb. 22	Dec. 21 Feb. 22	Dec. 23 Feb. 22	Dec. 28 Feb. 28	Dec. 30 Feb. 28
Mar. 7	8(.4707)	10(.4707)	7(.4707)		
14	6(.5268)	13(.5268)	7(.5268)	7(.4716)	7(.4716)
	3(.5800)		3(.5800)	8(.5539)	4(.5539)
21					1(.6205)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--					
	Emergence[1] of *Trichoplusia ni*				
	Insects originating in January				
	Jan. 6[2] Feb. 28[3]	Jan. 11 Feb. 28	Jan. 13 Feb. 28	Jan. 20 Mar. 3	Jan. 27 Mar. 3
Mar. 14	10(.4716)	11(.4184)	5(.4184)		
	8(.5539)	11(.4716)	12(.4716)	3(.4048)	
		2(.5539)	4(.5539)	19(.4871)	4(.4871)
21				4(.5537)	8(.5537)
				5(.6154)	4(.6154)
	Emergence of *Estigmene acrea*				
	Insects originating in second 2 weeks of July				
	July 20 Aug. 3	July 20 Aug. 6	July 22 Aug. 9	July 27 Aug. 9	July 29 Aug. 17
Aug. 17	35(.5264)	6(.4291)			
	1(.6136)	3(.5163)			
2	1(.8400)		18(.5115)	13(.5115)	
			5(.6433)	19(.6433)	5(.4003)
Sept. 7				4(.7844)	7(.5414)
				3(.9752)	10(.7322)
					1(.8694)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Estigmene acrea*							
	Insects originating in August							
	Aug. 3[2] Aug. 23[3]	Aug. 5 Aug. 23	Aug. 10 Aug. 25	Aug. 12 Aug. 25	Aug. 19 Aug. 31	Aug. 26 Sept. 10	Aug. 31 Sept. 17	
Aug. 31	1(.3675)							
Sept. 7	4(.5583)	7(.5583)	11(.4957)	2(.4957)				
14		4(.7612)	6(.6986)	23(.6986)				
21				1(.9828)	7(.6669)			
					2(.8141)	12(.4816)		
Oct. 5						12(.6494)	26(.4115)	
						1(.7026)	14(.4863)	
12							3(.5825)	
Mar. 21							1(1.8806)	
	Insects originating in September							
	Sept. 2 Sept. 20	Sept. 9 Sept. 24	Sept. 10 Sept 29	Sept. 14 Oct. 6	Sept. 16 Oct. 7	Sept. 21 Oct. 12	Sept. 23 Oct. 14	Sept. 28 Oct. 24
Oct. 5	12(.3919)							
12	11(.5327)	14(.5160)	4(.3838)					
19		4(.5599)	2(.4277)					
26			3(.4772)					
Nov. 8					1(.4116)			
23				1(.5393)				
30							1(.3973)	
Feb. 1					2(.8061)			
22			1(1.1181)	3(1.0056)	3(.9482)	1(.8304)	1(.7840)	6(.6582)
			3(1.1882)	3(1.0439)	4(1.0183)	1(.9005)	2(.8541)	6(.7283)
29		1(1.3652)	2(1.2330)	3(1.0887)			2(.8989)	
			1(1.2829)	1(1.1386)	6(1.1130)	1(.9952)	12(.9488)	2(.7731)

TABLE 6.--*Emergence of insectary-reared adults from larvae hatching on several dates from July 1971 to January 1972*--Continued

Week of--	Emergence[1] of *Estigmene acrea*							
	Insects originating in September--Continued							
	Sept. 2[2] Sept. 20[3]	Sept. 9 Sept. 24	Sept. 10 Setp. 29	Sept. 14 Oct. 6	Sept. 16 Oct. 7	Sept. 21 Oct. 12	Sept. 23 Oct. 14	Sept. 28 Oct. 24
Mar. 7				2(1.2183)	6(1.1710)		4(1.0068)	
				1(1.2758)	2(1.1927)		5(1.0860)	3(.8810)
14			1(1.4903)		2(1.3204)			
			2(1.5439)	2(1.3124)	4(1.3740)	1(1.1690)	4(1.1226)	
21						1(1.2981)		
Apr. 4				1(1.6915)	1(1.6659)	1(1.5481)	1(1.5017)	
11				2(1.8007)	2(1.7751)	1(1.7249)		
25					1(2.0843)			
May 2				1(2.1300)		1(2.1035)		
	Insects originating in October and December							
	Oct. 5 Nov. 4	Oct. 7 Nov. 18	Dec. 23 Mar. 3					
Feb. 22	1(.5366)	1(.4613)						
	3(.6067)	1(.5314)						
29		2(.5762)	2(.6028)					
Apr. 4			8(.6614)					
			5(.7120)					
11			8(.7796)					
25			1(1.0212)					
May 9			1(1.2470)					

[1]The number of moths emerged is followed in parentheses by the accumulated reciprocal units of development (RUD) for the pupal period. Accumulated RUD for nondiapausing insects are: *Heliothis zea*, 0.5; *Heliothis virescens*, 0.5; *Spodoptera exigua*, 0.4; *Trichoplusia ni*, 0.4; and *Estigmene acrea*, 0.35.
[2]The upper date is the week of origin.
[3]The lower date is the week of pupation.

TABLE 7.--*Accumulated reciprocal units of development (RUD) prior to the extended winter period, 1971*[1]

Week of pupation		Accumulated RUD prior to cold period				
		Bollworm	Tobacco budworm	Beet armyworm	Cabbage looper	Saltmarsh caterpillar
July	20	3.3834	3.2316	4.9668	4.8831	2.9935
	27	3.0459	2.9114	4.4602	4.4223	2.7203
Aug.	3	2.7336	2.6145	3.9905	3.9962	2.4666
	10	2.4659	2.3582	3.5892	3.6211	2.2400
	17	2.2151	2.1196	3.2203	3.2679	2.0269
	24	1.9789	1.8944	2.8723	2.9332	1.8217
	31	1.7007	1.6184	2.4306	2.5217	1.5758
Sept.	7	1.4302	1.3723	2.0549	2.1670	1.3611
	14	1.1454	1.1002	1.6269	1.7726	1.1253
	21	.9165	.8841	1.2883	1.4521	.9264
	28	.7250	.7006	1.0106	1.1737	.7516
Oct.	5	.5849	.5675	.8125	.9617	.6114
	12	.3993	.3885	.5432	.6894	.4404
	19	.3025	.2947	.4084	.5396	.3392
	26	.2316	.2275	.3114	.4261	.2595
Nov.	2	.1970	.1979	.2662	.3668	.2165
	9	.1178	.1155	.1520	.2466	.1360
	16	.0586	.0581	.0681	.1585	.0752
	23	.0383	.0328	.0440	.1216	.0445
	30	.0043	.0035	.0033	.0120	.0125

[1]May be subtracted from RUD accumulations in table to obtain spring accumulation.

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